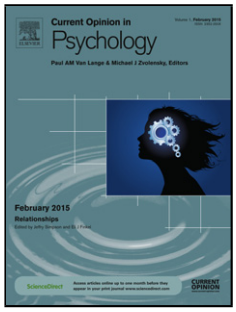

Title: Ego depletion in sports: Highlighting the importance of self-control strength for high-level sport performance<!–<RunningTitle>Ego depletion in sports</RunningTitle>–>

Author: Chris Englert

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Ego depletion in sports: Highlighting the importance of self-control strength for high-level sport performance

Chris Englert

Institute of Educational Science, Department of Educational Psychology, University of Bern, Switzerland

Correspondence concerning this article should be addressed to Chris Englert, University of Bern, Fabrikstrasse 8, CH-3012 Bern, Switzerland. E-mail: christoph.englert@edu.unibe.ch

Highlights.

- High levels of self-control are beneficial for sports performance.
- Ego depletion is associated with performance decrements in sports.
- Trait and state self-control predict exercise adherence and performance under pressure.

Abstract

Athletes are constantly confronted with self-control demands, but previous research has delivered sound empirical evidence that athletes are not always capable of dealing with these demands. According to the strength model of self-control, individuals have a limited amount of self-control strength, which can become temporarily depleted following self-control demands (e.g., attention regulation). When self-control strength is depleted, that is, in a state of ego depletion, athletes are less persistent during strenuous physical exercise, are less likely to follow their exercise regimens, and tend to perform worse under pressure. The aim of this review article is to highlight the importance of ego depletion in the field of sports and exercise and to discuss the recent research and controversies surrounding it.

Keywords: ego depletion, self-control, self-regulation, sports performance

Introduction

Athletes are regularly confronted with a diversity of self-control demands [1]: they must control their emotions during competitions [2], they must concentrate in high-pressure contexts [3], and they must resist immediate temptations in order to achieve long-term goals [4]. In this context, self-control can be defined as the ability to volitionally control certain behavioral tendencies or to resist immediate temptations in order to achieve long-term goals [5]. According to the strength model of self-control [5], all acts of self-control are based on a single metaphorical energy pool (i.e., self-control strength). Furthermore, different

personalities possess different capacities for this resource (i.e., some individuals are more adept at self-control than others) [6]. Apart from this trait component, individuals also differ in the amount of available self-control strength they can access in a given situation [7], as it can become depleted (i.e., ego depletion) for an extended period of time after having dealt with a primary self-control demand (e.g., emotion regulation during a sporting competition, working persistently on an unpleasant task). During such a state of ego depletion, performance impairments in subsequent self-control tasks are more likely to occur [8]. Traditionally, the effects of ego depletion have mainly been tested via a two-task paradigm [7] in which two groups of participants work on a similar first task, one of which requires self-control (leading to ego depletion) and one of which does not. The second task requires self-control from all participants (e.g., the Stroop task, [9]), and participants from the depletion condition tend to perform worse in the second task compared to participants from the non-depletion condition [8].

The aim of the present article is to highlight the importance and applicability of the strength model of self-control in the sports and exercise context by discussing the most recent research findings from the field. It begins by focusing on self-control and athletic performance, followed by a section on self-control and regular physical activity and a section on the importance of self-control for high levels of performance under pressure. The article concludes with a discussion of the validity of the strength model and offers suggestions for how athletes can improve their self-control.

Self-control strength and physical performance

Athletes must push themselves to their limits, as they often have to keep going even though their minds tell them to stop [10]. Overcoming these automatic urges to relax requires self-control and may be harder to accomplish in a state of ego depletion [11]. Dorris

et al. [12] found evidence for this theoretical assumption, as athletes in a state of ego depletion performed a lower number of pushups and sit-ups than those in a state with temporarily available self-control strength. Likewise, Wagstaff [13] reported that participants who had worked on a primary task requiring self-control displayed a lower mean power output in a 10-km cycling time trial than participants from a control condition [14].

Bray et al. [15, 16, 17] applied an isometric handgrip trainer in a series of studies, arguing that squeezing a handgrip as long as possible requires self-control because it becomes painful after a certain amount of time and requires individuals to force themselves to keep going despite the pain. Apart from the finding that the squeezing duration was significantly shorter in a state of ego depletion, Bray et al. [15] reported a significantly higher EMG activity in the working forearm muscles under ego depletion, indicating that ego depletion not only affects cognitive processing but also physiological parameters [see 16, 17].

Self-control strength and regular physical activity

Although individuals often intend to be physically active on a regular basis, there may be an intention–behavior gap regarding physical activity: individuals cannot consistently transform their intentions into workout behavior [18]. Regular physical activity is highly dependent on self-control, as individuals need to resist immediate, more attractive, and less exhausting temptations in order to follow their potentially straining workout schedules [4, 11, 19, 20]. Allom et al. [21] found evidence supporting this assumption, as participants with higher trait self-control strength were more physically active than participants with lower trait self-control strength [see 22, 25]. In the same vein, Toering and Jordet [23] reported that professional soccer players with higher trait self-control strength as opposed to lower trait self-control strength invested more time in their training regimens.

To investigate the role of state self-control on regular physical activity, Englert and Rummel [26] had participants perform a series of physical exercises every day for seven days and assessed their state self-control on a daily basis. The results revealed that individuals were less likely to perform their exercises on a given day when their state self-control had been low during that respective day. A longitudinal study by Martin Ginis and Bray [27] also showed that state self-control was related to exercise adherence, as individuals with temporarily depleted self-control strength were less likely to be physically active. Taken together, these studies suggest that high levels of both state and trait self-control strength are beneficial for regular physical activity.

Self-control strength and performance under pressure

In a series of studies, Englert and Bertrams [28, 29, 30] tested the assumption that the anxiety–performance relationship, often studied in sports psychology [31], is moderated by momentarily available self-control strength. Englert and Bertrams proposed that anxiety disrupts efficient attention regulation, which in turn affects performance in tasks for which selective attention regulation is inevitable (e.g., dart throwing [32]). According to Schmeichel and Baumeister [33], attention regulation is a self-control act, which is dependent on the momentary availability of self-control strength. In other words, acts of selective attention regulation should be impaired in a state of ego depletion. The results of these studies support the authors' hypothesis—there were only negative anxiety effects on sports performance in individuals with temporarily depleted self-control strength. For instance, anxious and ego-depleted participants performed worse in a dart throwing task, scored fewer basketball free-throws [28], were less adept at focusing their attention on the relevant target areas of a dart board [29], and were more likely to be distracted by irrelevant, potentially threatening stimuli while performing basketball free-throws [30]. Thus, self-

control strength seems to serve as a buffer against the negative effects of anxiety on attention regulation and performance.

Little research has been conducted regarding the importance of trait self-control strength for performance under pressure. A notable exception is a study by Landmann et al. [34], who found that higher levels of trait self-control strength were related to better performance under pressure. Although this study was conducted on a sample of police officers, not athletes, it revealed that high levels of trait self-control strength may be beneficial in preventing anxiety-related performance impairments.

Mechanisms of self-control

Although there is emerging evidence for the important role of self-control in sports and exercise contexts, the responsible mechanisms of how self-control affects performance have not been sufficiently investigated. Baumeister et al. [5, 7] proposed a metaphorical resource that can become depleted; however, it is unclear where this resource is located and whether there is a physiological resource that enables self-control. Previous research attempts have suggested that glucose may be the driving force behind the ego depletion effect [35], but recent studies have failed to find empirical support for this hypothesis [36]. Research in the neuropsychology field has revealed reduced activity in the lateral prefrontal areas of the brain following previous acts of self-control [37].

In addition to the discussion on the responsible neural and physiological aspects of self-control, scholars have debated the psychological variables that may cause the ego depletion effect. Graham and Bray [38] found that ego depletion led to lower levels of self-efficacy, which in turn negatively affected performance in the handgrip task. Apart from self-efficacy, it has been suggested that primary self-control efforts reduce motivation to engage in subsequent self-control acts [10]. This ongoing discussion regarding the

responsible mechanisms of the ego depletion effect and the non-significant findings of recent replication studies [39] make it crucial to analyze the conditions in which the ego depletion effect occurs and how it can be counteracted.

Ways to improve self-control strength and to prevent states of ego depletion

As outlined in the previous sections, high levels of self-control strength may be beneficial for successful performance. This raises the question of whether there are ways to boost self-control that may then enable athletes to perform at their peak level. A recent study by Bray et al. [40] suggested that regularly exerting self-control strength over a two-week period could improve self-control performance in the long run [see 41]. At baseline, participants performed a maximal incremental exercise test on a cycle ergometer in a state of ego depletion. Then, an experimental group was instructed to squeeze a handgrip twice per day for as long as possible for two weeks, which, as previously mentioned, is an act that requires self-control strength [15]. The control group did not receive any self-control training. After the two weeks, both groups were again instructed to take part in a maximal incremental exercise test on a cycle ergometer in a state of ego depletion. The results revealed a significant effect of self-control training on performance in the cycling task, as performance in the experimental group significantly improved after the two-week training while there were no improvements in the control group.

One way to prevent the negative effects of ego depletion may be to use implementation intentions [42, 43]. In this context, an individual would be asked to state a certain behavioral intention as well as to specify when and how to execute the respective intention (e.g., “If situation A occurs, then I will perform behavior B,” [43]). The aim is to create a cognitive association between the intention and the situation in which the intention is supposed to translate into actual behavior. When the situation occurs, the intended

behavior will be automatically activated without requiring any cognitive effort or self-control processes.

Friese et al. [44] proposed that mindfulness exercises might help individuals to avoid performance impairments following primary acts of self-control. The authors reported that mindful individuals were less likely to view challenging situations as stressful, and in general, were more adept at handling stressful situations. They explained that mindful individuals were less likely to experience inner conflicts between immediate temptations and long-term goals, as they would rather accept their desires and impulses than ruminate over the pros and cons of a certain behavior. If an individual does not experience any inner conflict between different goals, no self-control is necessary. How could these findings be applied to the field of sports and exercise? In stressful situations, athletes have a tendency to worry about their performance, which takes up cognitive resources and may lead to choking under pressure [45]. According to Birrer et al. [46], mindful individuals are less likely to be affected by these self-intrusive thoughts—they would rather accept these thoughts instead of try to actively suppress them. In this way, the constant rumination over the intrusive thoughts and the consequent additional load on cognitive resources can be prevented. Ego depletion and mindfulness have not been investigated together in sports and exercise contexts, but it would be beneficial to explore their relationship more in-depth in future research.

Conclusion

The studies reviewed in the present article highlight the importance of self-control strength in sports: low levels of self-control are associated with poor athletic performance in a wide variety of sports tasks [12, 13, 14, 15, 16, 17, 47], affect the likelihood of

successfully following workout plans [21, 22, 23, 24, 26, 27], and impair performance under pressure [28, 29, 30, 34].

Considering the recent failures to replicate the ego depletion effect, future studies should continue to explore mechanisms that may be responsible for this effect. Although there are ways to improve self-control strength, few studies have developed sports-specific self-control interventions [40], which is surprising given the potential benefits of high self-control strength. To conclude, self-control is an important aspect of competitive sports and exercise, but several open research questions still remain.

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Participants performed worse in a cycling task, generated lower mean power outputs, displayed a lower maximum heart rate, and reported higher physical exertion in a state of ego depletion as opposed to a state with temporarily available self-control strength.

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In a within-subject design, participants performed a cycling task measured at two intervals: once in a state of ego depletion and once in a state of temporarily available self-control strength. Under ego depletion, participants performed significantly worse in the cycling task.

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Trait self-control significantly correlated with physical activity, as individuals with higher trait self-control strength were more physically active than individuals with lower trait self-control strength, highlighting the importance of trait self-control strength.

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In professional soccer players, higher levels of trait self-control strength were associated with more time spent on the soccer field and with less time spent on social activities. This study demonstrates the positive effects of trait self-control on regular physical activity in professional athletes.

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[25] **Stork MJ, Graham JD, Bray SR, Martin Ginis KA: **Using self-reported and objective measures of self-control to predict exercise and academic behaviors among first-year university students**. *J Health Psychol* 2016. Advance online publication. DOI:10.1177/1359105315623627.

Trait and state self-control strength predicted adherence to exercise plans and academic behavior in a sample of 30 university students measured over a four-week period. This is one of the first studies to link the state and the trait components of self-control strength to exercise adherence.

[26] **Englert C, Rummel J: **I want to keep on exercising but I don't: The negative impact of momentary lack of self-control on exercise adherence**. *Psychol Sport Exerc* 2016, **26**:24-31. DOI:10.1016/j.psychsport.2016.06.001.

State self-control was reduced on days perceived to be rather stressful; further, lower levels of state self-control were associated with a lower likelihood to adhere to a workout schedule over a one-week period. Interestingly, trait self-control strength did not have a significant effect on exercise adherence.

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Under ego depletion, participants performed worse and on average displayed shorter final fixation durations on the relevant target areas in a dart throwing task under high pressure conditions, whereas performance and the accompanying gaze behavior did not suffer under pressure when participants' self-control strength had not been temporarily depleted by a primary task. This is the first study to link ego depletion to gaze behavior under pressure.

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Ego-depleted participants performed worse in a basketball free-throw task and were more distracted by an irrelevant audio stream under pressure than participants with

temporarily available self-control strength. These findings indicate that self-control strength may serve as a buffer against distractibility in high-pressure contexts.

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In a sample of police officers, trait self-control strength was related to shooting performance under pressure. Individuals with higher levels of trait self-control strength were less affected by the pressure context, prompting the authors to conclude that trait self-control strength may protect against pressure-related performance impairments.

[35] Gailliot MT, Baumeister RF: **The physiology of willpower: Linking blood glucose to self-control**. *Pers Soc Psychol Rev* 2007, **11**:303-327. DOI:10.1177/1088868307303030.

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Ego depletion was related to poorer physical performance. Additionally, self-efficacy was negatively affected by ego depletion and mediated the relationship between ego depletion and physical performance. These results demonstrate that self-efficacy is an important psychological variable that needs to be considered in self-control research.

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The "Registered Replication Report" did not find any evidence for the ego depletion effect. However, the authors strictly recommended not outright rejecting the strength model and denying that previous self-control acts may impair subsequent self-control performance; rather, they suggested thoroughly examining the psychological variables that may influence the ego depletion effect.

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One group of participants exerted self-control strength over a two-week period, whereas a second group of participants did not practice self-control regularly. Subsequent testing revealed that the first group displayed significantly better physical

performance in an endurance task than the second, indicating that practicing self-control may improve physical performance in the long run.

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